934

Alkaloid Hunting

About 950 alkaloids have been isolated and named from the two percent of all species which have been tested for them. As a guide in further search for alkaloids, their presence in and absence from some 250 families of plants are here tabulated.

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Introduction

Alkaloids have been known for a long time. Henry (8) states that the first crystalline one, narcotine, was obtained by Derosne in 1803. From then on, events occurred rather rapidly. Henry goes on to say: "Between 1817 and 1840 practically all the more important alkaloids were isolated, including emetine, veratrine, strychnine, piperine, caffeine, quinine, berberine, coniine, atropine, codeine, thebaine, cinchonine, hyoscyamine, curarine, quinidine, aconitine and colchicine". By the end of 1952 about 950 had been isolated and named. These had been found in about 77 families, 317 genera and 807 species. In addition to these alkaloids which have been named and their chemical characters determined in greater and less detail, the presence of alkaloids has been established in still another 20 families, about 220 genera and 395 species. Thus at the end of 1952 alkaloids were known to be present in aproximately 97 families, 519 genera and 1202 species. Even so, only 2% of all species are on record as having been tested for alkaloids.

Interest in alkaloids still continues. Pharmacognosists are still exploring the occurrence of particular alkaloids in the botanical world; pharmacologists are evaluating the physiological action of new ones brought to light; chemists are solving their structures and producing derivatives; nations are exploring their native flora for useful alkaloid drugs; and plant physiologists are still pondering the question, why do plants make all these nitrogenous compounds?

The purposes of the present article are to show the present world-wide interest in alkaloid studies, to put on record the statistics in this field up to the present, and to indicate where in the botanical world there may be profitable hunting in the future.

Recent and Present Activity

Probably the most intensive and extensive surveys of plants for alkaloids is that under way in Australia and reported on by L. J. Webb. He states: "A systematic field survey of the Queensland flora for alkaloids was begun by this Council in September 1944 as a continuation of the war-time project which aimed to grow important foreign drug plants in Australia, and to locate and develop substitutes from local plants for drugs in short supply. . . . Queensland was chosen as the first site

for surveying, since it offers diverse vegetational types and large areas of tropical rain forest". Three publications on this work have been issued (26–28). In addition, intensive chemical work has been started on the alkaloids of Australian Rutaceae (12).

Recently Russian expeditions went into Central Asia and the Trans-Baikal region to look for alkaloid-bearing plants, and 60 or more new species were found (7, 13, 17).

Arthur (1) screened over 200 species of plants in North Borneo.

In the Argentine Codoni (6) looked for alkaloids in the bark of native trees, and Novelli and Orazi (18) collected published information on the drug plants of the country.

In our laboratory an extensive survey of plants is under way, primarily to search for steroidal sapogenins. Incidental to this, qualitative tests for alkaloids and other groups of constituents were applied to all plant samples. Although the results for the first 1000 samples only have been published (24, 25), we are including here the alkaloid data on the first 3000 samples. The list includes species indigenous to the Americas and to South Africa, and exotic species grown in botanical gardens in the United States.

Besides the above regional surveys, in some countries particular plant families are being studied assiduously, not only as to occurrence of alkaloids but also as to their identification, structure and physiological activity. Thus in Canada it is the Papaveraceae (Fumariaceae) and Leguminosae (Papilionaceae) (15, 23); in New Zealand, Leguminosae (30); in Spain, Papilionaceae (19); in Japan, Menispermaceae, Berberidaceae and Magnoliaceae (20–22); in Russia, Ranunculaceae and Leguminosae (11, 32). In other places the field of study is more limited—*Mahonia* in India (3), *Holarrhena* in Germany (2), *Erythrina* in the United States (10).

A perennial field of study and speculation is the degree to which alkaloids "run in families", or, more generally stated, the relation of chemical constituents to taxonomy. Claus (5), using the occurrence of alkaloids as one of his criteria, concluded that in the Liliaceae "The taxonomy of this family as based on phytoconstituents appears to substantiate, in most instances, the taxonomy based on morphological characteristics". When he came to the whole plant kingdom, however, he (4) concluded: "At present, the role of phytoconstituents seems to have no relation to phylogenetic taxonomy, although possibilities for its use in general taxonomy are definite. The field of phytochemical investigation has much to offer before a complete relationship between the constituents of plants and the taxonomic arrangement of plants can be conclusively established".

Webb (28) gives considerable thought to the relation between alkaloids and taxonomy as he found it in Queensland plants. A few quotations will illustrate his deductions: "Within a family such as Apocynaceae, certain tribes contain alkaloidal species, while in other tribes such species are absent. . . . . Within genera such as *Evodia, Acronychia,* or *Melicope* in Rutaceae, it will be observed that comparatively few species contain alkaloids".

"The reason is obscure for this erratic occurrence of alkaloids among plants regarded as closely related on conventional taxonomic grounds. It is, however, less puzzling when other constituents besides alkaloids are considered. Thus, some local non-alkaloidal Rutaceae nevertheless contain chromenes and flavones of similar basic structure to the alkaloids in related species (*Melicope, Medicosma,* and *Evodia*). Apparently these species do share certain metabolic pathways which later diverge, depending on their evolutionary histories. . . . Chemical data have already proved of value in

the classification of several Queensland plants. *Zanthoxylum brachyacanthum* F. Muell. and *Z. veneficum* Bail. are chemically indistinguishable, and it is now realized that probably only one species is represented. On the other hand, *Strychnos psilosperma* F. Muell. and *S. arborea* A. W. Hill are doubtfully distinct botanically, yet differences between their alkaloids suggest that they should be separated".

Henry (9) cites many interesting examples on both sides of the question. In some cases alkaloids and taxonomy fit hand in glove; in others they bear no mutual relation. Perhaps the safest conclusion at present is that not enough plants have been studied as yet to justify deductions.

Lists of Alkaloid Plants

A list was compiled of the families, genera and species known to contain alkaloids. This was done by searching Wehmer (29), Henry (9), Manske and Holmes (16), Biological Abstracts through 1949 and Chemical Abstracts through 1952 and partly through 1953. A few items were picked up in other places.

These sources gave only the known occurrences, since in general negative findings, in this case known non-occurrence, do not appear in the technical literature. Since it is useful for an alkaloid hunter to know where alkaloids have been sought and not found, this information was also collected. The sources were largely Webb (26–28) who gives all results of alkaloid testing on a large number of Australian plants, and the 3000 samples at this laboratory mentioned above. A few other published non-occurrences of alkaloids were acquired in various places.

Besides listing the number of species, per family or per genus, known to contain or not to contain alkaloids, we thought it would be of interest and value to give the size of the family or the genus.[1] This would indicate the degree to which the family or genus has been explored. The total compilations resulting from these searches are formidable—so much so, in fact, that all of them cannot be presented here. Two tables were prepared, one by families and one by genera. Table I, given here, lists the major families generally recognized by botanists, about 235, the approximate number of species in each, and the number of species on which there is alkaloid information, either for its presence or absence. The following 48 families, with 238 species, which are extremely small and on which there is no alkaloid information, are not given in Table I. The number after the family is the number of species in it:

Achariaceae, 3
Adoxaceae, 1
Ancistrocladaceae, 12
Batidaceae, 1
Brunelliaceae, 8
Butomaceae, 9
Caryocaraceae, 15
Crypteroniaceae, 4
Cephalotaceae, 1
Ceratophyllaceae, 3
Cneoraceae, 12
Columelliaceae, 3
Coriariaceae, 10
Corynocarpaceae, 3
Crossosomataceae, 3
Cynocrambaceae, 2
Cynomoriaceae, 1
Datiscaceae, 5
Diapensiaceae, 10
Empetraceae, 8
Eucryphiaceae, 5
Geissolomataceae, 1
Ginkgoaceae, 1
Gomortegaceae, 1
Gonystilaceae, 7
Grubbiaceae, 3
Hydnoraceae, 7
Hydrocaryaceae, 11
Krameriaceae, 13
Lactoridaceae, 1
Leitneriaceae, 1
Lennoaceae, 5
Limnanthaceae, 8
Mayacaceae, 7
Myrothamnaceae, 2
Oliniaceae, 6
Opiliaceae, 6
Pentaphylacaceae, 2
Phrymaceae, 1
Salvadoraceae, 8
Saururaceae, 4

[1] Because of differences in concepts among botanists and because new discoveries are still being made, neither the size of the family nor of the genus can be given with absolute finality. The figures are, in general, conservative.

TABLE I

MAJOR FAMILIES OF FLOWERING PLANTS, WITH THE TOTAL NUMBER OF SPECIES AND THE NUMBER OF SPECIES WITH KNOWN POSITIVE OR NEGATIVE TESTS FOR ALKALOIDS

Species	Total	Alkaloids Pos.	Alkaloids Neg.
Acanthaceae	2,400+	3	6
Aceraceae	150	...	6
Actinidiaceae	285	...	1
Aizoaceae	600	5	4
Alismataceae	60	...	1
Amaranthaceae	800	2	14
Amaryllidaceae (1)	1,310	45	112
Anacardiaceae	600	1	15
Annonaceae	850	8	15
Apocynaceae	1,300	59	61
Aponogetonaceae	22	...	...
Aquifoliaceae	300	1	7
Araceae	1,500	...	13
Araliaceae	800	...	12
Aristolochiaceae	400	10	3
Asclepiadaceae	1,800	12	27
Balanophoraceae	40	...	1
Balanopsidaceae	10	...	1
Balsaminaceae	450	...	1
Basellaceae	22	...	...
Begoniaceae	800	...	1
Berberidaceae	200	29	4
Betulaceae	100	...	4
Bignoniaceae	750	2	33
Bombacaceae	140	...	11
Boraginaceae	2,000	18	26
Bromeliaceae	1,600	...	9
Bruniaceae	75	...	...
Burmanniaceae	60	...	...
Burseraceae	600	1	7
Buxaceae	50	3	2
Cactaceae	1,500	15	2
Callitrichaceae	25	...	...
Calyceraceae	40	...	...
Calycanthaceae	6	4	...
Campanulaceae	1,500	15	2
Canellaceae	2	...	1
Cannaceae	50	...	1
Capparidaceae	700	6	10
Caprifoliaceae	275	1	11
Caricaceae (2)	40	1	...
Caryophyllaceae (3)	2,100	...	3
Casuarinaceae	50	...	8
Celastraceae	500	10	22
Centrolepidaceae	32	...	...
Chenopodiaceae	1,400	12	22
Chlaenaceae	25	...	...
Chloranthaceae	40	...	...
Cistaceae	175	...	2
Clethraceae	30	...	1
Clusiaceae	400	...	...
Cochlospermaceae	25	...	3
Combretaceae	500	2	19
Commelinaceae	600	...	5
Compositae	20,000	82	115
Connaraceae	410	...	1
Convolvulaceae	1,200	4	15
Cornaceae (4)	112	5	4
Crassulaceae	800	2	3
Cruciferae	2,500	5	3
Cucurbitaceae	850	5	10
Cunoniaceae	240	3	10
Cycadaceae	100	...	1
Cyclanthaceae	45	...	...
Cyperaceae	3,200	...	2
Cyrillaceae	5	...	1
Dichapetalaceae (5)	125	1	1
Dilleniaceae	275	...	8
Dioscoreaceae (6)	650	6	54
Dipsacaceae	160	2	...
Dipterocarpaceae	350	...	...
Droseraceae	90	...	...
Ebenaceae	325	...	16
Elaeagnaceae	45	5	5
Elaeocarpaceae	125	...	9
Elatinaceae	30	...	1
Epacridaceae	350	...	8
Ericaceae	1,900	1	6
Eriocaulaceae	600	...	...
Erythroxylaceae	205	9	2
Eucommiaceae	2	...	2
Euphorbiaceae	7,300	13	73
Eupomatiaceae	2	...	2
Fagaceae	600	...	4
Flacourtiaceae (7)	850	3	23
Flagellariaceae	8	...	1
Fouquieriaceae	7	...	6
Frankeniaceae	34	...	2
Gentianaceae	800	6	1
Geraniaceae	850	2	3
Gesneriaceae	1,200	1	...
Globulariaceae	23	...	...
Gnetaceae	45	7	3
Goodeniaceae	300	...	11
Gramineae	5,000	10	16
Guttiferae (8)	750	...	14
Haemodoraceae	35	...	1
Haloragaceae	100	...	3
Hamamelidaceae	100	...	5
Hernandiaceae	25	3	2
Himantandraceae	2	1	...
Hippocastanaceae (9)	49	...	...
Hippocrateaceae	150	...	3
Humiriaceae	20	...	...
Hydrocharitaceae	90	...	...
Hydrophyllaceae	265	...	2
Icacinaceae	225	...	5

Species	Total	Alkaloids Pos.	Alkaloids Neg.
Iridaceae	1,500	...	14
Juglandaceae	60	...	3
Juncaceae	315	...	...
Juncaginaceae (10)	20	...	...
Labiatae	3,200	8	22
Lardizabalaceae	20	...	...
Lauraceae	1,100	25	24
Lecythidaceae	130	...	2
Leguminosae (11)	13,000	222	412
Lemnaceae	25	...	...
Lentibulariaceae	260	...	...
Liliaceae (12)	4,000	30	190
Linaceae	200	...	1
Loasaceae	250	...	...
Loganiaceae	800	24	9
Loranthaceae	1,100	2	9
Lythraceae	475	...	11
Magnoliaceae	100	3	2
Malesherbiaceae	30	...	...
Malpighiaceae	850	4	11
Malvaceae	1,500	3	26
Marantaceae	350	...	...
Marcgraviaceae	100	...	...
Martyniaceae	16	...	1
Melastomataceae	4,000	...	2
Meliaceae	800	3	26
Melianthaceae (13)	38	...	...
Menispermaceae	400	42	3
Monimiaceae	350	12	9
Moraceae	1,000	3	24
Moringaceae	10	...	1
Musaceae	150	...	2
Myoporaceae	110	2	5
Myricaceae	40	...	2
Myristicaceae	260	...	2
Myrsinaceae	1,000	...	9
Myrtaceae	3,000	1	67
Najadaceae	40	...	...
Nepenthaceae	60	...	...
Nolanaceae	60	...	...
Nyctaginaceae	250	2	5
Nymphaeaceae	90	4	...
Ochnaceae	375	...	2
Olacaceae	150	...	3
Oleaceae	500	6	30
Onagraceae	650	...	7
Orchidaceae	17,000	4	3
Orobanchaceae	140	...	1
Oxalidaceae	1,000	...	3
Palmae	4,000	1	51
Pandanaceae	300	...	3
Papaveraceae (14)	675	69	1
Passifloraceae	600	...	5
Pedaliaceae	50	...	...
Penaeaceae	25	...	...

Species	Total	Alkaloids Pos.	Alkaloids Neg.
Philydraceae	4	...	2
Phytolaccaceae	125	3	2
Pinaceae (15)	210	1	22
Piperaceae	2,000	11	3
Pittosporaceae	200	...	16
Plantaginaceae	200	...	3
Platanaceae	8	...	1
Plumbaginaceae	300	...	2
Podostemaceae	100	...	...
Polemoniaceae	265	...	1
Polygalaceae	700	1	3
Polygonaceae	800	5	17
Pontederiaceae	28	...	...
Portulacaceae	500	...	2
Potamogetonaceae	120	...	...
Primulaceae	800	...	...
Proteaceae	1,200	...	28
Punicaceae	2	1	...
Pyrolaceae (16)	32	...	1
Quiinaceae	20	...	...
Rafflesiaceae	22	...	...
Ranunculaceae	1,500	58	4
Rapateaceae	25	...	...
Resedaceae	70	...	...
Restionaceae	250	...	...
Rhamnaceae	550	3	16
Rhizophoraceae	70	...	3
Rosaceae	3,200	2	40
Rubiaceae	5,000	53	76
Rutaceae	1,300	74	99
Sabiaceae	65	...	...
Salicaceae	340	...	4
Santalaceae	250	3	3
Sapindaceae (17)	1,100	3	54
Sapotaceae	600	4	21
Sarraceniaceae	14	...	...
Saxifragaceae (18)	1,200	4	11
Scrophulariaceae	3,000	...	10
Simaroubaceae	200	4	11
Solanaceae	2,200	84	22
Sonneratiaceae	12	...	1
Sparganiaceae	20	...	1
Staphyleaceae	24	...	...
Stemonaceae	29	4	...
Sterculiaceae	750	3	24
Stylidiaceae (19)	125	...	3
Styracaceae	120	...	1
Symplocaceae	300	1	4
Taccaceae	30	...	...
Tamaricaceae	100	...	3
Taxaceae	13	3	...
Theaceae (20)	500	1	2
Theophrastaceae	60	...	1
Thymelaeaceae	500	1	11
Tiliaceae	400	...	15
Tremandraceae	30	...	1
Trigoniaceae	26	...	...

Species	Total	Alkaloids Pos.	Alkaloids Neg.
Triuridaceae	40	...	...
Tropaeolaceae	50	...	...
Turneraceae	105	...	...
Typhaceae	15	...	1
Ulmaceae	150	1	8
Umbelliferae	2,900	3	30
Urticaceae	600	1	9
Valerianaceae	370	1	...
Velloziaceae	170	...	1
Verbenaceae	2,600	6	38
Violaceae	850	1	4
Vitaceae	600	...	12
Vochysiaceae	80	...	...
Winteraceae	90	...	2
Xyridaceae	200	...	1
Zingiberaceae	1,400	...	3
Zygophyllaceae	200	3	3
Total	191,891	1,220	2,598

The following families, sometimes listed separately, are included in, or are synonymous with, the families given under the corresponding number: 1. Agavaceae; 2. Papayaceae; 3. Illecebraceae; 4. Alangiaceae, Garryaceae, Nyssaceae; 5. syn. Chailletiaceae; 6. Petermanniaceae; 7. Bixaceae; 8. Hypericaceae; 9. Aesculaceae; 10. syn. Scheuchzeriaceae; 11. Papilionaceae; 12. Philesiaceae, Trilliaceae; 13. syn. Bersamaceae; 14. Fumariaceae; 15. Taxodiaceae; 16. syn. Monotropaceae; 17. syn. Akaniaceae; 18. Escalloniaceae; 19. syn. Candolleaceae; 20. syn. Ternstroemiaceae.

Scytopetalaceae, 10
Stachyuraceae, 5–6
Stackhousiaceae, 2
Thelygonaceae, 2
Tovariaceae, 2
Trapaceae, 1
Trochodendraceae, 1

A generic table, published in processed form as a supplement to the present article (31), lists only those for which there is alkaloid information. Even so, the list has 1434 names, of which 519, or 36%, contain alkaloids. It may be obtained by writing to the United States Department of Agriculture, Eastern Utilization Research Branch, Philadelphia 18, Pennsylvania.

Where to Look for More Alkaloids

Taking a bird's-eye view of Table I, several items stand out. In the most-looked-into large families (Amaryllidaceae and Rutaceae), only 13% of the species have been examined. In general it is about 2%. Of 283 families (235 in the Table, 48 listed above), 99 of them, with 5700 species, have received no attention as to alkaloids. The following 12 rather large families have just been touched (the first figure is the number of species, the second the percentage of them for which there is alkaloid information):

Caryophyllaceae, 2100, 0.1
Compositae, 20,000, 1.0
Convolvulaceae, 1200, 1.5
Cruciferae, 2500, 0.3
Cyperaceae, 3200, 0.06
Ericaceae, 1900, 0.3
Gesneriaceae, 1200, 0.08
Gramineae, 5000, 0.3
Labiatae, 3200, 1.0
Melastomataceae, 4000, 0.05
Oxalidaceae, 1000, 0.3
Scrophulariaceae, 3000, 0.3

At the other extreme are five families which have been most examined:

Amaryllidaceae, 1300, 13
Berberidaceae, 200, 16
Menispermaceae, 400, 10
Pinaceae, 210, 10
Rutaceae, 1300, 13

Incidence of Alkaloid-Bearing Species

We know of only two sets of data in which both positive and negative species are listed. Webb handled 1793 species; 11% of these were positive. Our laboratory has screened about 1500 species; 5% of them gave positive tests for alkaloids. These are gross figures, of course, and embody all the known variables, such as plant part, age, locality, conditions of growth. The above per-

centages might be higher if all plant parts under all conditions had been tested. We believe it safe to say that five to ten percent of flowering plant species contain alkaloids.

A study of the supplementary table of genera discloses some other points of interest. Of the 1300 genera, 213 are large, containing 100 or more species. The largest are *Senecio* (Compositae) with 2000; *Astragalus* (Leguminosae) with 1600; *Solanum* (Solanaceae) with 1225; and nine others with 600 to 800. Some genera of note are:

Aconitum (Ranunculaceae), 110 species, 31 tested, all positive
Corydalis (Papaveraceae), 140 species, 26 tested, all positive
Lupinus (Leguminosae), 150 species, 22 tested, all positive

At the other extreme are some which gave all negative tests:

Agave (Amaryllidaceae), 275 species, 70 tested
Ficus (Moraceae), 800 and 16
Goodenia, 100 and 6
Hibbertia (Dilleniaceae) 100 and 5
Melaleuca (Myrtaceae) 100 and 7
Plectronia (Rubiaceae) 110 and 7
Terminalia (Combretaceae) 120 and 13
Yucca, 30 and 29

The table will be a guide to alkaloid hunters on a genus basis.

Where are the best prospects for alkaloid hunting? Using the data in Table I, this question can be approached from at least two viewpoints. Considering the size of the families and the proportion of positive species to date, the following would seem promising:

Amaryllidaceae	Papaveraceae
Boraginaceae	Ranunculaceae
Campanulaceae	Rubiaceae
Compositae	Rutaceae
Leguminosae	Solanaceae
Liliaceae	

Considering the size of the family and the paucity of information on them, pioneering work could be done in the following:

Acanthaceae	Labiatae
Cactaceae	Loranthaceae
Caryophyllaceae	Melastomataceae
Cruciferae	Myrsinaceae
Cyperaceae	Orchidaceae
Ericaceae	Oxalidaceae
Euphorbiaceae	Piperaceae
Gesneriaceae	Saxifragaceae
Gramineae	Zingiberaceae

Other considerations come in, of course, such as the availability of the family to the hunter. Furthermore, if the hunter has strictly in mind the ultimate growing of the alkaloid plant for commercial use, he would avoid some of the families named.

Still another viewpoint was submitted by McNair (14). Since electrolytes, including nitrogen compounds, are far higher in herbs than in trees and shrubs, he postulates that the law of mass action would indicate a greater number of organic compounds formed in herbs than in trees. After surveying the information available in 1941, he states: "Alkaloids have been found in three times as many herb families as tree families (19 vs. 6). The average molecular weight of alkaloids from tropical trees is much lower than that from tropical herbs". From this viewpoint the herbaceous families in the above list would offer the best hunting.

In the Gramineae eight alkaloids have already been found in 26 species examined. How many others will be detected in the rest of the 5000 species?

Nor is the hunting restricted to the flowering plants. Alkaloids have already been found in six families of fungi and in four of ferns. The ergot alkaloids have long been important in medicine.

Apparently the alkaloid hunter is not

entirely dependent on fresh plant material. Webb (28) was able, within certain limitations, to use herbarium material for qualitative tests.

The above discussion concerns the search for new alkaloid-bearing plants, irrespective of the nature of the alkaloids. When it comes to looking for a particular alkaloid, or a particular group of them, the information to date may or may not be of help, since there are examples in both directions. Thus nicotine is traditionally the alkaloid of *Nicotiana* (Solanaceae), but it has also been found in *Eclipta alba* (Compositae), *Asclepias syriaca* (Asclepiadaceae) and *Sedum acre* (Crassulaceae). Anabasine has been found in *Anabasis aphylla* (Chenopodiaceae) and in *Nicotiana glauca*. The berberine type of alkaloids occurs in six families. On the other hand, lycorine occurs only in the Amaryllidaceae; and since it has already been found in 14 genera and 21 species, one would expect to find it in many other places within the family, but probably not outside. Strychnine and brucine apparently occur in just one genus, *Strychnos* (Loganiaceae). Finding them in other places would appear to be highly unlikely; in fact it would be an event.

Within our present knowledge alkaloids occur singly in about half of the species containing them. In the rest, several may be found. In some cases the plant metabolism seems to run wild and turns out many closely related forms. For example, *Papaver somniferum* (Papaveraceae) has 25; each of eight species of *Erythroxylon* (Erythroxylaceae) has 14; *Corydalis tuberosa* (Fumariaceae) has about 17; *Holarrhena antidysenterica* (Apocynaceae) has 16.

Summary

A study was made of present activities in the field of alkaloids. Some surveys for alkaloid-bearing plants are made on a regional basis, as in Australia, Russia, Borneo and the Argentine. Other surveys concern particular families or genera. These surveys involve the search for new sources of known alkaloids, and for new alkaloids, followed by a study of their structure and their physiological properties.

Through 1952 some 950 alkaloids have been isolated and named, and in most cases their structures determined. These have been found in 98 families, 537 genera and 1200 species. A table of the 235 major plant families is given, showing for each family the total number of species and the number of species on which there is alkaloid information, either for its presence or absence. A supplementary table by genera, giving the same information, has been prepared and is available as a separate in processed form.

It is suggested that these tables may be of use to present or prospective alkaloid hunters. They indicate some 29 families where attention could be concentrated, either because of the size of the family and the known occurrence of alkaloids in them, or because they are large and almost entirely unexplored.

In general, alkaloids occur in five to ten percent of all species. The incidence is much higher in some families, much lower in others. The picture may change with more research, since there is a record of the presence or absence of alkaloids in only two percent of the 191,000 known species of flowering plants.

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